

## MINERALOGICAL DIFFERENCES BETWEEN METAMORPHOSED AND NON-METAMORPHOSED CM CHONDRITES.

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**Introduction:** Isotopic, mineralogical and chemical data show that there probably exists a subgroup of metamorphosed members within the CM chondrite clan. This subgroup is characterized by enrichment in heavy oxygen [1], which could be the result of parent body metamorphism of normal CM chondrites or of processing in a nebular reservoir enriched in <sup>18</sup>O [2,3]. Here we report on mineralogical differences between a new normal CM chondrite, Dho 955, and two metamorphosed CM chondrites (MCM chondrites), Dho 225 and Dho 735, recently found in Oman.

**Results:** The new carbonaceous chondrite Dho 955 is texturally similar to well-known CM chondrites and the Dho 225 and Dho 735 MCM chondrites. Irregular olivine aggregates, chondrules, CAIs, isolated mineral grains and their fragments are embedded in a fine-grained matrix. Some coarse-grained objects are surrounded by dark, fine-grained accretional dust mantles. POP and PO chondrules of Type I are common, but chondrules of Type II also occur. Two BO chondrules were found. CAIs consist of spinel, perovskite, and altered silicates. Chemical composition of olivine varies from Fa<sub>0.5</sub> to Fa<sub>35</sub>. Pyroxene is rare and represented by orthopyroxene (Fs<sub>1.4-5.6</sub> Wo<sub>0.8-2.4</sub>) and augite (Fs<sub>2.0</sub> Wo<sub>36.6</sub>). Compositions of olivines and pyroxenes correspond to those of CM chondrites in major and minor elements. The matrix composition of Dho 955 is in the range of CM chondrite matrices (Fig. 1).

Minor phases of Dho 955 include FeNi metal (kamacite), pentlandite, pyrrhotite, chromite, schreibersite, barringerite, P-rich sulfides, Ca-carbonates and eskolaite. Tochilinite is common. The chemical composition of tochilinite of Dho 955 is shown in Fig. 2. It is close to tochilinites of well-known CM chondrites [4]. P-rich sulfides are present as normal and Cr-rich members. Dho 955 is unusually enriched in these sulfides. Practically every second sulfide grain in this meteorite is P-rich. The S/P-(Fe+Ni)/P (at.) relationships (Fig. 3) of the Dho 955 sulfides are similar to those of other CM chondrites [e.g., 5]. Chemically, P-sulfides in Dho 955 are most similar to those in the Boriskino CM chondrite [5].

In Dho 225, we observed objects of tochilinite composition [2], but further investigation showed that they are fine-grained intergrowths of troilite and probably oxides. On the plot S-Fe/(Fe+Mg) they are between the compositions of troilite and tochilinites

from Dho 995 and other CM chondrites (Fig. 2). Synchrotron IR microspectroscopy (SIRM) [6] gave no signatures of O-H bonds (in structural OH and/or bound H<sub>2</sub>O) at 2.7-3  $\mu$ m in Dho 225 and Dho 735 matrices. This suggests a low content of hydrated phases, phyllosilicates and tochilinite. In contrast, the O-H absorption bands were identified by SIRMs in the matrix spectra of Cold Bokkeveld, Murray and Mighei, and in tochilinite spectra of Murray, studied for comparison. Further evidence for the dehydrated state of the Dho 225 and Dho 735 matrices are the position and shape of strong bands around 10  $\mu$ m due to Si-O vibrations, being consistent with fine-grained Fe-rich olivine. The positions and shapes of the Si-O bands in the IR spectra of the typical CM2 chondrite matrices are different, being consistent with mixtures of Fe-rich and Mg-rich phyllosilicates.

**Discussion:** Normal CM chondrites are not distinguishable from MCM chondrites in the chemical composition of the main phases, however, they differ in some accessories: MCM chondrites do not contain tochilinite and P-rich sulfides.

The lack of tochilinite in MCM chondrites could be explained by metamorphism. Tochilinite has a low thermal stability, decomposes at 245 °C to troilite and oxides [7], intergrowths which we observed in Dho 225. Another very important difference between CM chondrites and MCM chondrites is the presence of P-rich sulfides in CM chondrites and a lack of them in MCM chondrites. This is probably also due to thermal metamorphism. P-rich sulfides are also thermally unstable and can be easily converted to Ca-phosphate-troilite-pentlandite-chromite assemblages, which are very common in chondrites [e.g., 8,9].

**Conclusions:** As compared to normal CM chondrites the metamorphosed CM chondrites are characterized by: 1) a lack of tochilinite, and 2) a lack of P-rich sulfides. These features could be due to thermal metamorphism. However, it is still unclear how metamorphism could have affected the oxygen isotopic system and led to an enrichment in heavy oxygen. Pre-accretionary nebular thermal processing could have produces all features in just one step, no?

**Acknowledgments.** This project was supported by Austria-Russia projekt RFBR-BSTC (projekt Nr. I4/04, and grant 03-05-20008).

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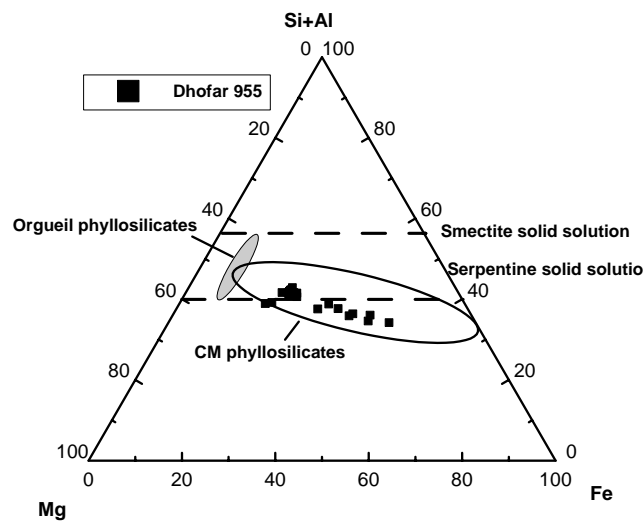


Fig. 1. Chemical compositions of matrix phyllosilicates in Dho 955.

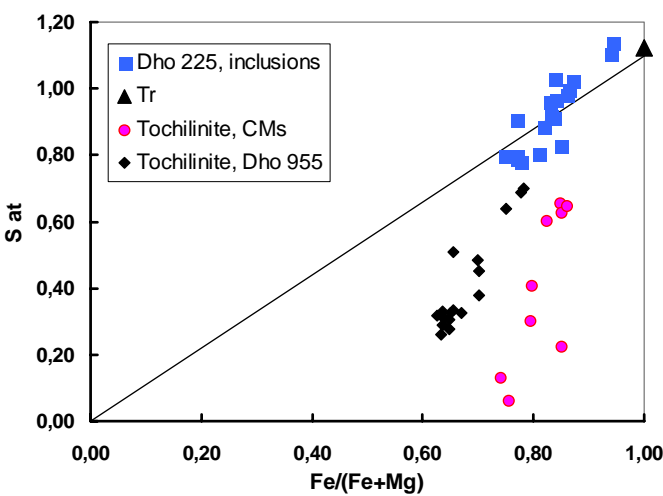


Fig. 2. Chemical compositions of troilite- rich inclusions of Dho 255 and tochilinite from CMs, and Dho 955.

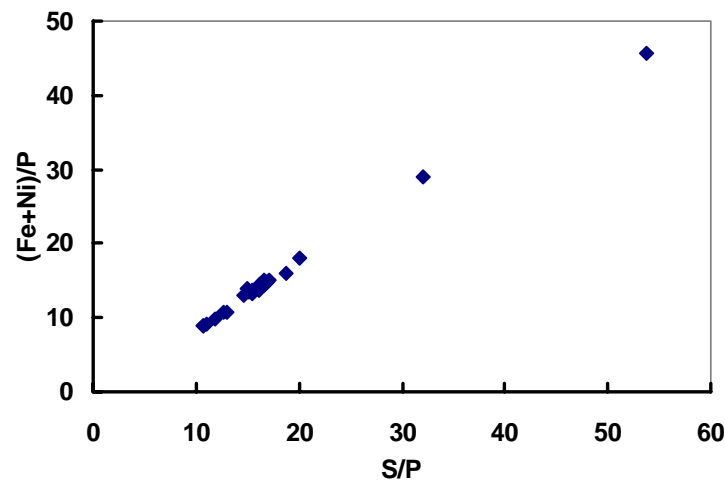


Fig. 3. S/P-(Fe+Ni)/P (at.) correlation in P-rich sulfides from Dho 955.